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Effects of MALEIC HYDRAZIDE On the Suitability of Tobacco For Cigarette Manufacture

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CONTENTS

Page

Summary 1

Introduction 6

Production aspects of the experiments

  Field treatments of the tobacco 8

  Yield and farm value of the tobacco 9

Evaluation by leaf experts 12

Laboratory evaluation of chemical and physical characteristics of leaf samples 17

Manufacture and evaluation of the cigarettes

  Preparation of cigarette blends 23

  Manufacture of the blended cigarettes 28

  Physical properties of the cigarettes 29

  Burning properties of the cigarettes 32

  Smoking panelists' evaluation of the cigarettes 34

Evaluation of flue-cured blends by United Kingdom manufacturers . . 40

Discussion 44

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The various forms of evaluation were all conducted under code; therefore, the participants did not know the treatments of the samples that they evaluated. The conclusions reached are those of the Agricultural Research Service, U.S. Department of Agriculture, and do not necessarily represent the opinions of the cooperators in the State experiment stations, in the tobacco industry, or in chemical manufacture.

EFFECTS OF MALEIC HYDRAZIDE ON THE SUITABILITY OF TOBACCO FOR CIGARETTE MANUFACTURE

R. N. Jeffrey and E. L. Cox[1]

SUMMARY

Experiments on the effects of sucker control with maleic hydrazide on the suitability of the tobacco for cigarette manufacture, similar to those conducted on the 1960 crop, were conducted on the 1961 crop of tobacco grown in Florida, Georgia, North and South Carolina, Virginia, Tennessee, Kentucky, West Virginia, and Maryland. Tobacco treated with maleic hydrazide at the rate recommended by the manufacturer was compared with that suckered by hand. Three times of application of the chemical were used: (1) Full flower as described on the manufacturer's label, (2) about 1 week earlier, and (3) about 1 week later. This range in plant maturity is frequently encountered in different plants in a single field.

Various means of estimating suitability of the tobacco for cigarette manufacture gave the following results:

(1) In judging coded flue-cured leaf samples displayed on the warehouse floor, leaf experts of the manufacturing companies showed a statistically significant preference for hand-suckered tobacco over maleic hydrazide-(MH) treated tobacco. This was particularly true for the samples from the top and the middle of the plant. The leaf experts did not consistently exhibit a statistically significant preference for a particular sucker-control treatment of burley and Maryland tobacco.

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[1] Plant Physiologist and Biometrician, respectively, Agricultural Research Service, U.S. Department of Agriculture.

(2) Statistically significant differences between hand-suckered flue-cured tobacco and that in which sucker growth had been controlled with MH at any of the three times of treatment were demonstrated by laboratory tests. MH treatments lowered the specific volume (filling power) and increased the sugar content and equilibrium moisture content of tobacco from the top, middle, and bottom of the plant. These treatments also significantly lowered the total ash, alkalinity of the water-soluble ash, and alkalinity of the total ash of samples from the upper part of the plant.

(3) Portions of the flue-cured tobacco from each treatment used in this experiment were evaluated by the principal tobacco manufacturers of the United Kingdom. Their independent findings generally confirmed the results of the tests conducted in the United States.

(4) The laboratory tests on air-cured tobacco samples showed differences related to sucker-control treatment statistically significant when the samples from all leaf levels were combined. The specific volume (filling power) and total alkaloid content of MH-treated samples were significantly lower, and the equilibrium moisture content and alpha amino nitrogen values were significantly higher than those of hand-suckered samples. When the analytical values of the smaller number of samples taken at each leaf level separately were treated statistically, significant differences usually were not observed. In view of the smaller differences in chemical composition associated with the sucker-control treatment and the decrease in differences detectable by leaf experts, the effect of MH on the suitability of burley and Maryland tobacco for cigarette manufacture is probably less pronounced than its effect on the suitability of flue-cured tobacco.

(5) The present experiments confirmed all previous ones in showing that the filling power of MH-treated tobacco is less than that of hand-suckered tobacco. This property was determined on tobacco treated at three stages of maturity in comparison with hand-suckered tobacco. It was also measured by three methods: (a) by measuring the volume of weighed samples, (b) by finding how much extra tobacco was required to make a cigarette of standard "draw," and (c) by finding how much extra tobacco was required to make a cigarette of standard compressibility. The average reduction in filling power based on these nine comparisons was 6.5 percent.

(6) No serious mechanical difficulty related to sucker-control treatment was observed in the operation of the cigarette-making machines when U. S. blend cigarettes were manufactured from the 1961 crop tobacco, though it had been observed when they were manufactured from the 1960 crop. Serious difficulty was encountered in the United Kingdom in making cigarettes from subsamples of the flue-cured portion of the tobacco described in this report.

(7) When members of expert smoking panels smoked cigarettes made of MH-treated tobacco in comparison with cigarettes made of hand-suckered tobacco, a preference, significant by statistical test, was recorded in favor of the hand-suckered tobacco if the MH had been applied at full flower or later.

(8) On the plots in which the tobacco used in this evaluation was grown, the average yield per acre was not significantly affected by time of application of MH but was greater when this means of sucker control was used than when flue-cured or burley tobacco was hand suckered. The average yield following MH treatment of flue-cured tobacco was 300 pounds per acre

greater and of burley was 140 pounds greater, but it did not increase the yield of Maryland tobacco. The U. S. standard grades did not distinguish the effects of these sucker-control practices; therefore, the calculated average prices were the same irrespective of sucker-control treatment. If it is assumed that these prices represent real sale prices, one could calculate that the acre returns would be proportional to yields in all three types, being about $200 per acre higher for flue-cured tobacco after sucker control with MH than after hand suckering. The difference would be about $100 for burley, but none for Maryland tobacco.

Although the above type of calculations by means of U. S. standard grades has been widely used to evaluate tobacco quality, the estimate of the value of the suckering practice obtained by this means is completely different from that obtained on the basis of buyers' appraisals of the leaf or of smokers' evaluation of cigarettes made from tobacco suckered by different methods. Obviously the last two methods are much more closely related to suitability for manufacture than is a grading system set up before chemical sucker control was known.

(9) When the results obtained from the 1961 crop were compared with those from the 1960 crop, similar conclusions were reached on many points:

(a) Leaf experts selected hand-suckered flue-cured tobacco as more suitable for use than the MH-treated tobacco, but they did not make a similar selection in burley or Maryland tobacco.

(b) Laboratory determination proved that MH-treated tobacco differed significantly from hand-suckered tobacco grown under otherwise similar conditions, especially in filling power, moisture absorption, sugar content (flue-cured only), and ash constituents.

(c) The expert smoking panel members discriminated against cigarettes made of tobacco treated with MH at the earlier time only in 1960 but at full flower and later only in 1961. Considering the results of both years, they did not always discriminate in favor of cigarettes made of hand-suckered tobacco and against those made of MH-treated tobacco, but they sometimes discriminated against these cigarettes if the tobacco had been treated at any stage of plant maturity at which the chemical is ordinarily used.

INTRODUCTION

At the request of the Tobacco Subcommittee of the Committee on Agriculture of the House of Representatives, a report was submitted by the Department of Agriculture in April 1961 on the effects of maleic hydrazide on the suitability of tobacco for cigarette manufacture. This report appeared subsequently under the designation ARS 34-29 [2] as part of a regular publication series to make it available for citation and library cataloging.

Since the effects of seasonal conditions on agricultural crops differ from year to year and that report was based principally on the 1960 crop, requests were received from both agricultural and tobacco manufacturing interests for the repetition of the experiments on the 1961 crop. Through the cooperation of the agricultural experiment stations of all the principal cigarette tobacco-growing States and of the principal cigarette manufacturers of the United States and the United Kingdom, this has been done.

In this study, like the previous one, the tobacco was grown in experimental plots by research workers. The various treatments were carefully defined and were applied as uniformly as can be done in field trials by different research workers at different locations. The cured tobacco from each location was evaluated under code by leaf experts of the different tobacco manufacturers. The physical and chemical properties that are used to determine tobacco suitability were measured on the samples under code in the laboratories of the principal manufacturers. The tobacco was subject to accelerated aging, and that from various locations (but given the same sucker-control treatment) was blended in proportions similar to those ordinarily used in cigarette manufacture and then made into cigarettes. These cigarettes under code were smoked by expert tobacco smoking panels, and all pertinent results were subjected to statistical evaluation.

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[2] Anonymous. The Effects of Maleic Hydrazide on the Suitability of Tobacco for Cigarette Manufacture. Agr. Res. Serv. ARS 34-29, Aug. 1961.

This report describes the field treatments to make the results understandable. Limited data belonging to the field workers at the various locations are combined to present some of the farm aspects of this problem. However, this report, like the previous one, is concerned principally with estimates of the suitability of the tobacco for cigarette manufacture rather than with the production of the tobacco.

This report concerns the effects of maleic hydrazide (herein referred to as MH) on the suitability of tobacco for use; however, other practices, held constant in this study, also affect suitability or quality. These include fertilization, methods of control of diseases and insects, spacing, time of harvest, curing, and the selection of varieties.

PRODUCTION ASPECTS OF THE EXPERIMENTS

Field Treatments of the Tobacco.--The field treatments of the tobacco grown in 1961 were among those planned by the Regional Sucker Control Committee and they were conducted by members of that Committee. The treatments evaluated were similar to those of the 1960 crop previously described.[3/] In 1961 the Hicks variety was used at all locations where flue-cured tobacco was tested. Because of disease problems, this necessitated moving the North Carolina test from Oxford to Whiteville. In the burley area, Burley 21 was grown at all locations except Greeneville, Tenn., where Burley 37 was used. The locations were the same as in 1960 except for addition of Princeton, Ky.

All plots were again located in areas controlled by the State experiment stations and all phases of culture were supervised by men trained in tobacco research methods. Thus the treatments were conducted with closer attention to amount of chemical used and times of application than can be obtained on most farms. The times of application used are defined in words and pictures in appendix figure 1 in the previous report. Briefly, these are as follows: The plants were topped at full flower, defined as the time of shedding of the first corolla. One week before this, the plants of one treatment were sprayed with the commercial formulation of MH at the rate of 1 pint per 1,000 plants. This treatment is referred to in the tables as "1 week earlier" or "earlier." Immediately after topping, the plants in another treatment were sprayed at the same rate. This treatment is referred to in

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[3/] See footnote 2, p. 6.

the tables as the "full flower" stage. A week after topping, the plants of a third treatment were sprayed at the same rate, suckers having been removed by hand if necessary. This is referred to as "1 week later" or just "later." The tobacco of the treatment referred to as "hand suckered" or "hand" was suckered manually whenever suckers reached a length of 4 to 6 inches. At each location at least 4 replicates of each treatment were grown. In tables 1 through 6, the two instances where the treatment deviated from standard are identified and described.

Since the experimental plots were small and located in areas selected for uniformity, the directions could be followed closely as to time of topping and treatment, whereas in most large fields the date of flowering or stage of maturity of some of the plants differs by more than the 2 weeks between the earliest and latest treatment used in these experiments.

Yield and Farm Value of the Tobacco.--The yield per acre, average price per hundred pounds (calculated by means of the U. S. official standard grades assigned by Federal graders to each priming and the average sale price of these grades), and the resultant average value per acre of the flue-cured tobacco grown at each location are shown in tables 1, 2, and 3 respectively. Similar data for the burley and Maryland tobaccos are shown in tables 4, 5, and 6. The average increase in yield of flue-cured tobacco due to MH treatment was over 16 percent and of burley tobacco nearly 6 percent. The price per hundred pounds as here calculated is not significantly related to suckering treatment. This confirms previous results which have shown that the present grade standards do not distinguish the effects of this treatment.

Table 1.--Effects of sucker-control practices on yields per acre of 1961 crop flue-cured tobacco grown at various locations

Location	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
	Pounds	Pounds	Pounds	Pounds
Gainesville, Fla.	1,844	[1]2,293	2,304	2,201
Tifton, Ga.	1,762	2,098	2,088	1,973
Florence, S. C.	1,680	1,967	1,941	1,868
Whiteville, N. C.	2,163	2,403	2,518	2,400
Chatham, Va.	1,463	-----	1,503	1,374
Average including Chatham	1,782	-----	2,021	1,963
Average excluding Chatham[2]	1,862	2,190	2,213	2,111

Table 2.--Effects of sucker-control practices on average prices per hundred pounds calculated from U. S. Official Standard Grades of 1961 crop flue-cured tobacco grown at various locations

Location	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
Gainesville, Fla.	$63.59	[1]$63.35	$63.76	$63.57
Tifton, Ga.	61.72	62.40	62.26	61.99
Florence, S. C.	68.79	68.48	69.33	70.20
Whiteville, N. C.	67.26	67.98	66.86	66.88
Chatham, Va.	58.03	-----	58.42	57.79
Average including Chatham	63.88	-----	64.13	64.09
Average excluding Chatham[2]	65.34	65.55	65.55	65.66

Table 3.--Effects of sucker-control practices on average values per acre calculated from U. S. Official Standard Grades of 1961 crop flue-cured tobacco grown at various locations

Location	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
Gainesville, Fla.	$1,173	[1]$1,452	$1,469	$1,399
Tifton, Ga.	1,088	1,310	1,301	1,223
Florence, S. C.	1,155	1,347	1,345	1,311
Whiteville, N. C.	1,455	1,634	1,684	1,606
Chatham, Va.	849	-----	878	749
Average including Chatham	1,144	-----	1,335	1,267
Average excluding Chatham[2]	1,218	1,436	1,450	1,385

[1] At this location the tobacco in this treatment was topped a week before full flower and sprayed at full flower.

[2] Since one treatment was omitted at Chatham, Va., data from this location must be omitted to obtain a comparable average.

Table 4.--Effects of sucker-control practices on yields per acre of 1961 crop air-cured tobacco grown at various locations

Tobacco type and location	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
	Pounds	Pounds	Pounds	Pounds
Burley:				
Greeneville, Tenn.	1,986	2,231	2,034	2,047
Waynesville, N. C.	2,564	2,583	2,750	2,891
Lexington, Ky.	2,168	2,275	2,089	2,157
Princeton, Ky.	2,046	2,012	2,141	1,958
Glade Spring, Va.	2,347	2,877	2,827	1/ 2,441
Point Pleasant, W. Va.	3,088	2,987	3,454	3,326
Burley average	2,367	2,498	2,549	2,470
Maryland:				
Upper Marlboro, Md.	1,448	1,466	1,382	1,355
Average of air-cured	2,235	2,347	2,382	2,311

Table 5.--Effects of sucker-control practices on the average prices per hundred pounds calculated from U. S. Official Standard Grades of 1961 crop air-cured tobacco grown at various locations

Tobacco type and location	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
Burley:				
Greeneville, Tenn.	$66.31	$65.88	$66.14	$65.75
Waynesville, N. C.	68.50	68.00	68.25	68.75
Lexington, Ky.	70.10	70.22	69.90	70.20
Princeton, Ky.	69.06	68.44	68.47	69.25
Glade Spring, Va.	68.08	67.82	67.36	1/ 65.50
Point Pleasant, W. Va.	66.68	65.63	67.21	67.87
Burley average	68.12	67.67	67.89	67.89
Maryland:				
Upper Marlboro, Md.	69.50	70.30	70.20	69.10
Average of air-cured	68.32	68.04	68.22	68.06

Table 6.--Effects of sucker-control practices on the average values per acre calculated from U. S. Official Standard Grades of 1961 crop air-cured tobacco grown at various locations

Tobacco type and location	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
Burley:				
Greeneville, Tenn.	$1,318	$1,471	$1,345	$1,348
Waynesville, N. C.	1,752	1,756	1,879	1,980
Lexington, Ky.	1,520	1,598	1,460	1,510
Princeton, Ky.	1,413	1,377	1,466	1,356
Glade Spring, Va.	1,598	1,951	1,904	1/ 1,533
Point Pleasant, W. Va.	2,055	2,229	2,324	2,257
Burley average	1,609	1,730	1,730	1,664
Maryland:				
Upper Marlboro, Md.	1,006	1,031	971	937
Average of air-cured	1,523	1,630	1,621	1,560

1/ At this location the tobacco in this treatment was sprayed at full bloom and topped 1 week later.

Thus, the calculated acre values were increased by MH treatment over hand suckering by essentially the same proportion as the yield per acre was increased. The calculated increase amounted to an average of about $200 per acre in the flue-cured and $100 in burley tobacco. No increased value was obtained for Maryland tobacco because this type was harvested sooner after topping than burley. In flue-cured and burley tobacco, the increase in income calculatd in this way was considerably greater than the saving in costs resulting from MH treatment as compared with hand suckering if all labor had been hired. The estimate of the value of this suckering practice derived from this means of calculation was completely at variance with the results of the methods of estimation of the suitability of the resulting tobacco for cigarette manufacture that follow. Since the U. S. standard grades were set up before chemical suckering was discovered, perhaps they should not be expected to be useful in evaluating this practice.

EVALUATION BY LEAF EXPERTS

Only the leaves of the top two-thirds of the plants were evaluated in 1960, but in 1961 all marketable leaves were included. Thus, five to seven (usually six) primings of flue-cured and usually six farm grades of the air-cured stalk-cut types were evaluated from each location and each treatment. Each sample was evaluated under code by leaf experts from five or six companies working separately. The leaf experts were asked to indicate the order of suitability for their company of the tobacco of the same farm grade from the different treatments. The tobacco sample assigned first choice was given a score of 4 and so on down to 1 for the least suitable. The averages of these scores from all companies for the flue-cured tobacco from Florida, Georgia, North and South Carolina are shown in table 7. Since the physiological activity of the leaves at different levels on the plant at the time of treatment varies, the results are shown separately for the grades from the bottom third, middle third, and top third of the plant.

If the leaf experts had in every case chosen as most suitable the leaf from the same treatment, it would have received a score of 4.00. If they had not been able to distinguish samples from different treatments, each sample would have received a score of about 2.50. Among samples from the top and middle of the flue-cured plant, statistically significant preference (table 7) was shown for the hand-suckered samples over all MH-treated samples. The hand-suckered samples from the bottom of the plant were preferred over all except the later treatment. The leaf experts rated the tobacco treated at the time recommended by the manufacturer somewhat lower than that treated at other times.

The leaf experts chose between samples representing the four different treatments on 186 occasions, considering all companies, locations, and plant positions. Their first choice was the hand-suckered sample 55 percent of the time when they were choosing among samples from the top of the plant, 53 percent when choosing among samples from the middle of the plant, and 36 percent when choosing samples from the bottom of the plant. It would have been about 25 percent if they had been completely unable to distinguish suckering effects.

Table 7.--Suitability,[1] as judged by leaf experts, of flue-cured tobacco from different sucker-control treatments

Part of plant and location	Hand suckered	Time of maleic hydrazide treatment: 1 week earlier	Time of maleic hydrazide treatment: At full flower	Time of maleic hydrazide treatment: 1 week later	Difference for discrimination[2]
Bottom:					
Gainesville, Fla.	3.29	2.25	1.79	2.67	
Tifton, Ga.	2.30	2.75	1.79	3.16	
Florence, S. C.	2.88	2.38	2.54	2.20	
Whiteville, N. C., rep. 1	2.08	2.54	2.42	2.96	
Whiteville, N. C., rep. 2	3.05	2.17	2.20	2.58	
Average	2.72	2.42	2.15	2.72	0.28
Middle:					
Gainesville, Fla.	3.59	2.37	1.63	2.41	
Tifton, Ga.	3.04	2.79	1.63	2.54	
Florence, S. C.	3.21	1.95	2.29	2.55	
Whiteville, N. C., rep. 1	2.36	2.61	1.83	3.20	
Whiteville, N. C., rep. 2	3.75	2.33	2.08	1.84	
Average	3.11	2.43	1.89	2.57	0.28
Top:					
Gainesville, Fla.	2.67	3.00	1.92	2.41	
Tifton, Ga.	3.21	2.20	2.25	2.34	
Florence, S. C.	2.33	2.00	3.00	2.67	
Whiteville, N. C., rep. 1	3.46	2.42	2.08	2.04	
Whiteville, N. C., rep. 2	2.83	2.67	1.87	2.63	
Average	2.93	2.40	2.26	2.42	0.28

[1] Based on a scale of 1 to 4, 1 being least desirable and 4 most desirable.

[2] Value needed to discriminate between the hand-suckered and another treatment by a t test at the 5-percent level of significance.

In a similar evaluation of air-cured tobacco (burley and Maryland) (table 8) the leaf experts were unable, by the means available to them on the warehouse floor, to distinguish between treatments to a degree that would be expected to influence the market price. They showed a statistically significant preference for the hand-suckered sample over the earlier MH-treated sample from the top of the plant and over the earlier and later MH-treated samples from the middle, but a statistically significant preference for the earlier MH-treated samples over hand-suckered samples from the bottom of the plant. When all leaf levels were combined, no significant preferences were shown. The percentages of first choice for the hand-suckered samples were 23, 28, and 27, respectively at the bottom, middle, and top of the plant.

When these results are considered along with those obtained on the previous crop, the general conclusions are similar; i.e., that leaf experts can detect to some degree the effects of suckering flue-cured tobacco with MH, but they do not distinguish the effects to a practical degree in burley or Maryland tobacco when the chemical is applied in a controlled manner.

Table 8.--Suitability,[1] as judged by leaf experts, of air-cured (burley and Maryland) tobacco from different sucker-control treatments

Part of plant and location	Hand suckered	Time of maleic hydrazide treatment			Difference for discrimination[2]
		1 week earlier	At full flower	1 week later	
Bottom:					
Greeneville, Tenn., rep. 1	2.60	2.90	2.90	1.60	
Greeneville, Tenn., rep. 2	2.15	2.65	2.90	2.30	
Waynesville, N. C.	2.20	2.80	2.63	2.37	
Lexington, Ky., rep. 1	2.35	2.95	2.20	2.50	
Lexington, Ky., rep. 2	2.95	2.85	2.15	2.05	
Princeton, Ky.	2.25	2.65	2.80	2.30	
Glade Spring, Va.	2.45	2.86	2.50	2.17	
Point Pleasant, W. Va.	2.40	1.97	3.03	2.60	
Upper Marlboro, Md.	2.50	3.20	2.10	2.20	
Average	2.42	2.73	2.60	2.25	0.17
Middle:					
Greeneville, Tenn., rep. 1	2.35	3.25	2.45	1.95	
Greeneville, Tenn., rep. 2	2.25	2.30	2.75	2.70	
Waynesville, N. C.	2.90	2.10	3.10	1.90	
Lexington, Ky., rep. 1	3.25	2.65	1.70	2.40	
Lexington, Ky., rep. 2	2.95	1.65	3.25	2.15	
Princeton, Ky.	2.80	2.60	2.20	2.40	
Glade Spring, Va.	2.40	2.20	2.20	3.20	
Point Pleasant, W. Va.	3.40	2.40	2.40	1.80	
Upper Marlboro, Md.	2.60	1.70	2.80	2.90	
Average	2.75	2.30	2.59	2.36	0.26
Top:					
Greeneville, Tenn., rep. 1	2.45	2.20	3.10	2.25	
Greeneville, Tenn., rep. 2	3.30	2.00	2.15	2.55	
Waynesville, N. C.	3.20	1.45	1.95	3.40	
Lexington, Ky., rep. 1	2.15	3.50	1.75	2.60	
Lexington, Ky., rep. 2	2.60	2.30	2.60	2.50	
Princeton, Ky.	2.15	3.05	2.95	1.85	
Glade Spring, Va.	2.65	2.35	2.40	2.60	
Point Pleasant, W. Va.	3.20	2.40	2.20	2.20	
Upper Marlboro, Md.	2.60	2.07	2.93	2.40	
Average	2.69	2.35	2.47	2.48	0.26

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[1] Based on a scale of 1 to 4, 1 being least desirable and 4 most desirable.

[2] Value needed to discriminate between the hand-suckered and another treatment by a *t* test at the 5-percent level of significance.

LABORATORY EVALUATION OF CHEMICAL AND PHYSICAL CHARACTERISTICS OF LEAF SAMPLES

The methods of preparation of samples for chemical analysis [4] and the methods of analysis [5] were similar to those used on the 1960 crop. Since leaf from the bottom third of the plants of the 1961 crop was analyzed, the number of samples rose from 152 in the 1960 crop to 177 in the 1961 crop even though not as many replicate plots were analyzed separately.

The results for all samples of flue-cured tobacco are given in table 9. The average analytical values of the samples from the bottom, middle, and top of the plant and for the plant taken as a whole are given in table 10. In the instances in which the averages of MH-treated samples differ to a statistically significant degree from the corresponding hand-suckered samples, the results are underlined in table 10.

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[4] See footnote 2, p. 6.

[5] R. N. Jeffrey. Detailed Data for the Information of Cooperators in the Study of Effects of Maleic Hydrazide on the Suitability of Tobacco for Cigarette Manufacture. June 30, 1961. (Copies available by request.)

Table 9. Physical and Chemical Analyses of Flue-cured Tobacco Samples by State, Plant Position, and Sucker Control Treatment

State	Plant	Sucker Control Treatment[1/]	Code	Color	Specific Vol.	Moisture Equilibrium at 60% RH %	Total Ash %	Alkalinity of Water Sol. Ash meq./10 g	Alkalinity of Total Ash meq./10 g	Total Nitrogen %	Acid Insol. N %	Alpha Amino N %	Total Alkaloids %	T.V.B. %	T.V.B. Nicotine %	Nicotine in T.V.B. Distillate %	Reducing Sugars %	Water Sol. Acids meq./10 g	pH	Pet. Ether Extract %	M.H. ppm
Fla.	Bottom	Hand	FB4	30	4.68	14.2	15.41	1.88	12.61	1.99	0.80	0.195	2.42	0.45	0.25	0.20	17.63	3.46	5.28	7.7	3.1
		Earlier	FB3	27	4.52	14.8	15.76	1.45	11.89	2.01	.78	.161	2.65	.45	.23	.22	18.77	3.59	5.21	7.4	26.4
		Full flower	FB1	21	4.40	14.9	15.08	2.36	12.38	2.00	.81	.265	2.30	.37	.18	.19	18.89	3.59	5.20	7.0	57.1
		Later	FB2	22	4.42	14.8	15.29	1.63	12.30	2.06	.59	.186	2.45	.41	.21	.20	18.18	3.55	5.23	7.8	29.9
	Middle	Hand	FM1	28	4.90	15.1	10.11	2.35	12.21	2.29	.96	.182	2.98	.46	.21	.25	18.85	4.01	5.26	7.5	4.3
		Earlier	FM2	26	4.10	16.4	9.27	1.94	10.24	2.23	.91	.172	3.26	.47	.21	.26	24.13	4.21	5.10	5.7	27.0
		Full flower	FM3	30	4.26	16.7	9.22	2.23	15.30	2.15	.89	.231	2.76	.47	.24	.23	25.40	3.96	5.11	6.4	29.8
		Later	FM4	25	4.42	16.0	9.78	2.30	12.04	2.26	.86	.188	3.06	.47	.22	.25	22.52	4.24	5.16	6.5	25.1
	Top	Hand	FT3	29	5.86	13.7	9.34	1.94	12.21	2.35	.90	.247	3.48	.51	.25	.26	15.11	4.15	5.18	8.2	6.3
		Earlier	FT4	27	4.84	14.6	10.24	2.07	12.08	2.45	.92	.239	3.90	.55	.23	.32	15.72	4.68	5.13	7.6	21.7
		Full flower	FT2	28	4.60	16.1	8.67	1.76	10.03	2.46	.93	.197	3.84	.55	.24	.31	21.66	4.56	5.20	7.5	32.2
		Later	FT1	27	5.22	14.7	9.72	2.06	12.42	2.55	.89	.239	3.80	.57	.26	.31	17.20	4.45	5.28	8.2	17.0
Ga.	Bottom	Hand	GB5	55	4.98	13.58	18.99	3.55	14.91	1.87	.75	.230	1.66	.37	.23	.14	15.87	3.66	5.17	5.4	3.4
		Earlier	GB2	62	4.76	14.05	17.46	2.54	18.08	1.91	.75	.240	1.68	.39	.25	.14	18.59	3.84	5.09	5.4	100.4
		Full flower	GB3	56	4.90	13.81	17.98	4.25	16.13	1.91	.81	.220	1.69	.37	.23	.14	17.49	3.85	5.10	5.2	52.0
		Later	GB1	53	4.90	14.09	17.60	2.32	17.01	1.94	.78	.220	1.65	.38	.23	.15	17.70	3.93	5.08	5.3	5.9
	Middle	Hand	GM1	32	4.38	15.77	12.22	1.54	9.42	2.07	.90	.178	3.17	.51	.25	.26	19.73	4.36	5.13	5.5	1.7
		Earlier	GM5	35	4.10	16.02	12.56	1.93	10.35	1.94	.79	.144	2.59	.40	.20	.20	21.22	4.04	5.15	5.0	48.1
		Full flower	GM6	39	4.08	15.90	11.63	2.18	10.05	1.97	.80	.161	2.73	.42	.19	.23	22.71	4.15	5.11	4.7	47.6
		Later	GM4	27	4.34	15.95	11.96	2.08	9.79	2.08	.92	.170	3.08	.49	.23	.26	21.65	4.51	5.05	5.4	82.3
	Top	Hand	GT1	7	4.12	17.73	10.30	2.22	10.07	2.44	.85	.216	4.30	.66	.31	.35	17.11	5.31	4.98	6.2	8.0
		Earlier	GT6	14	3.66	16.79	9.56	1.73	8.60	2.20	.88	.135	3.60	.52	.22	.30	22.21	4.90	4.99	5.4	37.7
		Full flower	GT4	6	3.66	16.94	8.76	1.75	8.62	2.35	.92	.154	3.74	.54	.22	.32	22.37	4.92	4.98	5.3	41.7
		Later	GT2	7	3.76	17.00	9.07	1.55	8.46	2.42	.81	.170	4.39	.57	.21	.36	21.99	5.35	4.92	5.8	69.0
S. C.	Bottom	Hand	SB2	39	5.06	13.97	17.53	1.56	14.48	1.69	.72	.221	1.60	.30	.19	.11	17.34	3.52	5.29	5.1	18.2
		Earlier	SB1	33	4.98	13.85	19.88	1.70	14.25	1.64	.71	.186	1.41	.29	.19	.10	18.06	3.49	5.19	4.5	192.9
		Full flower	SB3	37	4.96	13.87	18.47	1.55	13.41	1.63	.70	.222	1.45	.32	.20	.12	17.96	3.55	5.25	5.0	272.0
		Later	SB4	45	5.14	14.01	17.69	1.72	14.55	1.68	.72	.212	1.43	.30	.19	.11	16.86	3.58	5.21	5.1	286.4
	Middle	Hand	SM1	33	4.54	15.33	13.48	2.68	12.71	1.75	.72	.160	2.04	.35	.18	.17	19.93	3.80	5.39	5.1	8.1
		Earlier	SM4	33	4.10	16.34	12.79	3.19	11.79	1.67	.70	.126	1.74	.29	.18	.11	27.23	3.46	5.38	5.2	111.0
		Full flower	SM2	23	3.98	16.45	12.00	2.98	11.02	1.64	.72	.143	1.85	.28	.14	.14	24.98	3.47	5.39	5.1	109.1
		Later	SM3	31	4.26	16.06	13.01	2.79	11.91	1.69	.93	.143	1.90	.34	.19	.15	24.05	3.57	5.37	4.6	186.7
	Top	Hand	ST3	48	4.24	15.28	9.94	2.21	11.14	2.16	.85	.220	3.15	.47	.23	.24	18.81	4.29	5.28	6.7	8.4
		Earlier	ST4	49	3.80	16.19	8.21	2.25	9.19	1.95	.93	.161	2.59	.38	.18	.20	23.71	3.79	5.28	5.5	87.8
		Full flower	ST1	44	3.80	16.36	8.19	1.75	9.82	2.01	.96	.152	3.05	.43	.19	.24	23.86	4.02	5.23	6.2	91.6
		Later	ST2	50	3.82	16.06	8.76	2.22	10.00	2.03	.98	.178	3.06	.42	.18	.24	23.05	4.13	5.20	6.5	112.6
N. C.	Bottom	Hand	N1B4	61	4.78	11.99	15.13	6.37	22.04	2.00	.78	.196	1.26	.35	.24	.11	17.49	2.49	5.72	5.6	4.7
			N2B4	48	5.70	12.65	19.00	6.47	25.30	1.65	.78	.221	1.36	.29	.17	.12	11.58	2.02	5.95	5.6	5.3
		Earlier	N1B1	47	4.48	14.58	14.47	6.23	20.51	1.48	.71	.134	1.09	.30	.21	.09	22.15	2.45	5.62	4.8	28.7
			N2B1	40	5.12	13.70	16.48	6.04	22.86	1.55	.78	.165	1.35	.33	.22	.11	17.91	2.25	5.85	5.0	25.3
		Full flower	N1B2	58	4.44	13.76	13.69	6.49	20.24	1.61	.78	.177	1.41	.35	.23	.12	19.44	2.59	5.67	5.4	81.3
			N2B2	45	5.04	14.19	15.76	4.94	21.44	1.65	.82	.195	1.46	.35	.23	.12	17.23	2.62	5.69	5.3	61.0
		Later	N1B3	65	4.76	13.74	15.42	7.46	23.32	1.65	.80	.182	1.41	.33	.21	.12	15.54	2.41	5.81	5.5	68.5
			N2B3	43	5.02	13.71	16.49	6.30	22.76	1.71	.81	.200	1.45	.29	.18	.11	15.16	2.52	5.68	5.7	54.8
	Middle	Hand	N1M1	55	4.28	14.22	9.92	1.75	12.35	1.68	.87	.172	1.72	.34	.19	.15	21.20	2.95	5.51	6.6	3.6
			N2M1	60	4.54	13.98	10.24	3.58	13.58	1.69	.87	.150	1.77	.36	.21	.15	19.89	3.13	5.28	6.3	5.7
		Earlier	N1M2	54	3.82	14.36	8.40	3.43	12.57	1.53	.83	.107	1.51	.31	.19	.12	24.01	2.77	5.42	6.4	18.4
			N2M2	52	4.16	14.49	8.94	3.11	12.81	1.54	.85	.129	1.67	.28	.15	.13	23.38	2.72	5.40	6.2	22.8
		Full flower	N1M3	50	3.92	15.42	9.14	3.86	12.26	1.75	.73	.134	2.24	.35	.18	.17	24.05	2.91	5.52	6.9	52.9
			N2M3	48	4.02	14.80	8.99	2.69	12.19	1.77	.84	.126	2.20	.35	.18	.17	22.90	3.05	5.40	5.9	54.8
		Later	N1M4	49	4.00	14.96	10.00	3.84	13.35	1.68	.58	.134	2.15	.36	.18	.18	21.87	3.03	5.52	6.1	81.6
			N2M4	42	4.16	14.77	9.69	2.82	12.86	1.71	.83	.130	2.13	.33	.16	.17	22.74	2.89	5.45	5.9	81.3
	Top	Hand	N1T1	33	4.14	12.80	10.36	4.68	15.71	1.91	.81	.177	2.53	.45	.25	.20	15.15	3.15	5.69	8.3	3.0
			N2T1	39	4.40	12.82	9.50	5.31	15.15	1.97	.82	.208	2.74	.48	.26	.22	14.36	3.30	5.57	4.9	4.0
		Earlier	N1T4	35	3.78	13.56	8.83	4.45	12.56	1.80	.83	.185	2.31	.39	.21	.18	18.05	3.09	5.62	8.0	29.3
			N2T4	38	4.16	13.75	7.93	4.40	12.43	1.84	.93	.212	2.58	.39	.18	.21	18.81	3.29	5.39	7.3	39.2
		Full flower	N1T3	14	3.64	14.29	9.18	3.68	12.13	2.27	.96	.177	3.23	.53	.26	.27	17.54	3.64	5.50	8.1	80.1
			N2T3	23	3.88	14.24	8.56	4.11	12.97	2.32	1.07	.200	3.51	.49	.32	.17	16.07	3.64	5.55	7.5	79.7
		Later	N1T2	18	3.76	14.02	9.35	3.79	12.56	2.25	.92	.195	3.25	.54	.26	.28	16.16	3.62	5.59	7.2	106.2
			N2T2	26	3.92	14.11	8.94	4.70	13.10	2.25	.91	.199	3.57	.50	.22	.28	15.85	3.62	5.50	6.9	111.9
Va.	Bottom	Hand	VB2	20	5.04	12.32	18.35	6.17	27.09	2.08	.88	.267	2.75	.42	.20	.22	6.23	2.86	5.59	6.8	2.7
		Full flower	VB1	26	5.14	12.30	17.90	5.14	24.59	2.02	.85	.275	2.59	.41	.19	.22	7.07	3.10	5.52	6.4	51.3
		Later	VB3	19	5.56	11.75	19.54	5.30	25.83	1.98	.93	.268	2.37	.38	.19	.19	5.44	2.60	5.62	7.0	11.4
	Middle	Hand	VM1	25	4.06	14.58	11.66	5.07	17.91	2.59	.97	.253	4.13	.60	.27	.33	11.81	4.65	5.21	6.8	2.2
		Full flower	VM3	32	3.96	14.98	11.24	4.67	16.95	2.50	1.04	.193	3.89	.54	.23	.31	14.22	4.57	5.15	6.5	20.3
		Later	VM2	24	4.06	14.44	12.27	5.57	18.83	2.35	1.02	.210	3.63	.49	.19	.30	13.22	4.34	5.22	6.7	20.9
	Top	Hand	VT3	0	4.06	12.68	11.50	5.73	17.41	3.20	1.25	.446	4.84	.81	.40	.41	4.65	4.36	5.43	7.2	1.9
		Full flower	VT2	0	3.88	13.64	10.51	4.70	14.57	2.96	.75	.314	3.82	.64	.32	.32	8.18	4.46	5.21	7.4	26.8
		Later	VT1	0	4.14	12.83	11.87	5.63	17.44	2.84	1.17	.353	4.07	.69	.36	.33	6.16	4.04	5.39	7.2	13.7

[1/] Hand = Topped at full flower and hand suckered whenever suckers were 4 to 6 inches long.
Earlier = Sprayed with maleic hydrazide about a week before full flower, topped at full flower.
Full flower = Topped at full flower and sprayed with maleic hydrazide immediately after topping.
Later = Topped at full flower and sprayed with maleic hydrazide one week later, suckered then if necessary.

Table 10.--Mean values of the results of physical and chemical determinations on flue-cured tobacco samples as influenced by position on the plant and by sucker control treatment [1]

Determination	Bottom				Middle				Top				Whole plant			
		Time of maleic hydrazide treatment				Time of maleic hydrazide treatment				Time of maleic hydrazide treatment				Time of maleic hydrazide treatment		
	Hand suckered	1 week earlier	At full flower	1 week later	Hand suckered	1 week earlier	At full flower	1 week later	Hand suckered	1 week earlier	At full flower	1 week later	Hand suckered	1 week earlier	At full flower	1 week later
Color	47	42	43	46	42	40	38	35	31	33	23	26	40	38	35	35
Specific volume	5.04	4.77	4.75	4.85	4.53	4.06	4.05	4.24	4.55	4.05	3.92	4.10	4.71	4.29	4.24	4.39
Moisture equilibrium at 60% RH (%)	13.28	14.20	14.11	14.07	14.88	15.52	15.85	15.55	14.47	14.98	15.59	15.18	14.21	14.90	15.18	14.93
Total ash (%)	17.21	16.81	16.20	16.50	11.19	10.39	10.20	10.80	9.89	8.95	8.67	9.17	12.77	12.05	11.69	12.19
Alk. of water sol. ash (meq/10g)	3.97	3.59	3.92	3.89	2.38	2.72	2.79	2.77	3.27	2.98	2.61	2.86	3.21	3.10	3.11	3.17
Alk. of total ash (meq/10g)	17.87	17.52	16.72	17.99	12.05	11.55	12.16	11.99	12.86	10.97	10.71	11.31	14.26	13.35	13.20	13.76
Total N (%)	1.84	1.72	1.76	1.81	1.90	1.78	1.86	1.88	2.17	2.05	2.28	2.30	1.97	1.85	1.97	2.00
Acid insol. N (%)	.77	.75	.78	.74	.86	.82	.80	.82	.85	.90	.97	.90	.83	.82	.85	.82
Alpha amino N (%)	.213	.177	.216	.200	.168	.136	.159	.153	.214	.186	.176	.196	.198	.166	.184	.183
Total alkaloids (%)	1.66	1.64	1.66	1.68	2.34	2.15	2.36	2.46	3.24	3.00	3.47	3.61	2.41	2.26	2.50	2.59
Total volatile bases (% as NH_3)	.35	.35	.35	.34	.40	.35	.37	.40	.51	.45	.51	.52	.42	.38	.41	.42
TVB-Nicotine (%)	.22	.22	.21	.20	.21	.19	.19	.20	.26	.20	.25	.23	.23	.20	.22	.21
Nicotine in TVB distillate (%)	.14	.13	.14	.14	.20	.16	.19	.20	.25	.24	.26	.29	.20	.18	.20	.21
Reducing sugars (%)	15.98	19.10	18.20	16.69	19.92	23.99	24.01	22.57	16.11	19.70	20.30	18.85	17.34	20.93	20.84	19.37
Water soluble acids (meq/10g)	3.03	3.12	3.24	3.20	3.65	3.44	3.51	3.65	4.04	3.95	4.16	4.23	3.57	3.51	3.64	3.69
pH	5.48	5.39	5.38	5.40	5.31	5.29	5.31	5.31	5.34	5.28	5.29	5.30	5.38	5.32	5.33	3.34
Pet. ether extract (%)	5.88	5.42	5.58	5.88	6.20	5.70	5.80	5.70	6.86	6.76	6.92	6.92	6.3	6.0	6.1	6.2
Maleic hydrazide (ppm)	6.9	74.7	104.7	89.1	4.7	45.5	58.8	91.4	5.9	43.1	65.1	83.3	5.9	54.5	76.2	88.0

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[1] The mean values, which are underlined, differ significantly by statistical test from the corresponding values for hand-suckered tobacco samples.

The specific volume was lower in the samples from the MH-treated plots by an amount that corresponds to a reduction of filling power of 5 percent at the bottom of the plant, 9 percent at the middle, and 11.6 percent at the top of the plant, compared with the corresponding samples from hand-suckered plots. The moisture content at equilibrium with air of 60 percent relative humidity, the reducing sugar content, and of course the MH residue were increased at all leaf levels by chemical treatment. The alkalinity of the water soluble ash was reduced at the middle of the plant, and this value and the total ash and alkalinity of the total ash were reduced at the top of the plant. The total nitrogen and total alkaloid values appeared to be reduced at the earlier time of treatment but increased at the full flower and the later time of treatment.

The results for all air-cured samples are shown in table 11 and the averages, together with their statistical significance, are shown in table 12. The mean values for the whole plant, shown at the right side of table 12, are significantly lower for specific volume and alkaloid content and higher for equilibrium moisture and alpha amino nitrogen content in MH-treated than in hand-suckered samples. However, when the smaller number of samples available at each leaf level is considered separately, the differences do not consistently reach the 5-percent level of significance. At the individual leaf levels the only determination yielding consistently significant results is that of MH residue, though a number of the determinations referred to above show consistent trends at all leaf levels.

Table 11.--Physical and Chemical Analyses of Air-cured Tobacco Samples by Location Where Grown, Plant Position, and Sucker Control Treatment

Location Where Grown	Plant	Sucker Control Treatment[1]	Code	Color	Specific Vol.	Moisture Equilibrium at 60% RH %	Total Ash %	Alkalinity of Water Sol. Ash meq./10 g	Alkalinity of Total Ash meq./10 g	Total Nitrogen %	Acid Insol. N %	Alpha Amino N %	Total Alkaloids %	T.V.B. %	T.V.B. Nicotine %	Nicotine in T.V.B. Distillate %	Water Sol. Acids meq./10 g	pH	Pet. Ether Extract %	M.H. ppm
Greene-ville, Tenn.	Bottom	Hand	T1B4	54.0	8.24	12.34	22.79	17.06	38.71	2.63	1.26	0.153	1.23	0.39	0.28	0.11	0.29	7.51	5.8	4.7
			T2B3	53	8.88	12.01	23.89	15.90	39.56	2.47	1.26	.113	1.09	.32	.22	.10	.00	7.89	5.8	5.1
		Earlier	T1B1	55	7.94	12.55	24.69	18.17	39.96	2.55	1.37	.144	1.11	.38	.28	.10	.27	7.59	5.5	19.2
			T2B4	52	8.52	11.99	23.73	14.68	38.72	2.46	1.31	.141	1.21	.35	.25	.10	.00	7.68	6.4	39.8
		Full flower	T1B2	52	8.46	12.47	25.67	15.49	39.46	2.52	1.31	.140	1.09	.32	.24	.08	.00	8.05	5.6	33.0
			T2B1	53	8.84	12.13	23.62	15.24	39.01	2.45	1.32	.136	1.07	.37	.28	.09	.00	7.70	6.1	17.5
		Later	T1B3	49	7.98	12.44	26.48	18.68	40.93	2.66	1.38	.148	.96	.31	.24	.07	.00	8.40	5.5	76.4
			T2B2	58	8.26	12.15	22.90	13.91	38.94	2.51	1.34	.145	1.28	.41	.31	.10	.21	7.48	5.8	98.5
	Middle	Hand	T1M3	47	7.42	11.97	18.35	13.52	31.83	3.21	1.22	.341	3.27	.71	.40	.31	2.05	6.39	6.6	3.4
			T2M1	50	8.08	11.66	19.42	11.66	30.56	2.58	1.09	.235	2.80	.66	.40	.26	1.77	6.47	7.1	2.6
		Earlier	T1M4	47	7.32	12.36	19.03	13.05	30.17	3.35	1.30	.467	2.80	.75	.48	.27	2.28	6.20	5.9	40.4
			T2M3	43	7.32	12.02	18.38	10.78	28.86	3.18	1.24	.444	3.14	.76	.46	.30	2.44	6.18	7.1	35.1
		Full flower	T1M1	46	7.80	12.11	18.94	12.59	29.85	2.96	1.17	.362	2.89	.73	.44	.29	2.07	6.30	7.3	26.9
			T2M2	49	8.10	11.58	19.40	13.05	31.07	2.63	1.09	.245	2.82	.61	.35	.26	1.75	6.45	7.4	13.2
		Later	T1M2	46	7.74	12.11	19.64	14.90	30.74	3.10	1.21	.401	2.76	.73	.47	.26	1.87	6.50	6.5	75.8
			T2M4	51	7.42	11.72	18.91	11.57	30.91	2.80	1.17	.308	2.94	.65	.38	.27	1.99	6.32	7.0	81.5
	Top	Hand	T1T1	35	6.36	12.20	16.53	11.45	26.74	4.19	1.28	.818	3.90	1.10	.72	.38	3.45	5.88	6.7	3.4
			T2T4	34	6.52	11.33	16.47	9.08	26.32	3.50	1.17	.628	3.39	.93	.61	.32	3.15	5.89	7.6	5.7
		Earlier	T1T3	33	5.96	12.57	15.77	10.28	22.82	4.26	1.50	.925	2.78	1.06	.81	.25	3.44	5.71	6.3	77.3
			T2T1	34	6.34	12.04	15.48	8.02	22.06	3.95	1.49	.766	2.74	1.07	.81	.26	3.11	5.79	6.7	84.2
		Full flower	T1T2	35	6.42	12.01	16.61	11.11	24.67	3.69	1.28	.672	3.22	.94	.63	.31	2.99	5.93	7.2	46.3
			T2T2	33	6.28	11.52	17.03	10.09	25.99	3.46	1.15	.649	3.23	.92	.61	.31	2.82	5.98	7.2	20.9
		Later	T1T4	34	6.40	12.31	17.46	11.13	26.31	4.07	1.33	.816	3.28	1.06	.75	.31	2.56	6.00	6.7	158.7
			T2T3	33	6.10	11.67	16.41	9.46	25.35	3.94	1.18	.793	3.86	1.03	.70	.33	3.43	5.80	7.1	141.1
Waynes-ville, N. C.	Bottom	Hand	CB2	65	6.68	12.00	19.42	11.33	34.25	3.21	1.19	.364	4.19	.72	.33	.39	2.25	6.50	6.7	6.5
		Earlier	CB1	63	6.12	12.07	20.07	9.42	32.63	3.11	1.24	.448	3.20	.66	.37	.29	2.01	6.59	6.3	20.9
		Full flower	CB4	61	6.44	11.96	19.20	9.16	32.03	3.12	1.10	.406	3.46	.68	.32	.36	2.26	6.50	6.4	27.3
		Later	CB3	62	6.30	12.25	19.94	9.37	31.92	3.43	1.13	.481	4.06	.72	.35	.37	2.49	6.50	6.0	27.7
	Middle	Hand	CM4	45	5.54	12.94	14.64	12.42	28.64	4.48	1.65	.730	5.89	1.19	.65	.54	3.71	6.22	6.6	7.1
		Earlier	CM2	43	5.78	12.35	14.71	9.52	26.95	4.05	1.24	.709	3.97	.94	.57	.37	2.69	6.33	6.6	22.7
		Full flower	CM3	42	5.84	12.62	14.57	10.92	26.78	4.10	1.25	.699	4.52	1.12	.69	.43	3.28	6.30	7.3	40.4
		Later	CM1	39	5.40	13.03	15.05	10.61	27.17	4.66	1.24	.807	5.68	1.32	.78	.54	3.64	6.25	6.5	51.5
	Top	Hand	CT3	38	4.92	12.65	12.74	8.93	24.68	5.00	1.47	.915	5.50	1.37	.86	.51	4.16	5.71	6.1	7.8
		Earlier	CT1	43	5.40	12.94	11.10	7.73	18.07	4.28	1.89	.636	2.51	.82	.58	.24	2.87	5.82	6.6	43.1
		Full flower	CT2	42	5.40	12.64	11.94	9.62	21.51	4.25	1.59	.736	3.77	1.09	.75	.34	3.53	5.75	6.7	49.8
		Later	CT4	40	5.02	12.74	13.23	9.29	23.83	4.89	1.48	.934	5.19	1.38	.85	.53	4.37	5.78	6.2	49.0
Lexington, Ky.	Bottom	Hand	K1B2	73	8.38	11.41	19.97	13.34	32.91	3.36	1.91	.205	1.27	.32	.21	.11	.37	6.71	4.6	2.8
			K2B4	71	8.02	11.36	18.71	13.19	32.10	3.60	1.95	.248	1.76	.32	.17	.15	1.21	6.68	5.6	17.0
		Earlier	K1B1	74	8.06	11.50	19.55	13.12	31.21	3.54	1.96	.240	1.37	.35	.22	.13	1.06	6.70	5.0	21.3
			K2B3	69	8.32	11.28	20.16	14.46	34.74	3.35	1.91	.191	1.16	.27	.17	.10	.62	7.11	5.0	18.7
		Full flower	K1B3	71	7.92	11.53	19.88	14.24	33.19	3.47	1.97	.240	1.31	.36	.25	.11	.98	6.78	4.5	58.2
			K2B2	70	7.94	11.30	19.58	12.28	31.05	3.29	1.83	.222	1.26	.28	.17	.11	.85	6.85	5.7	76.0
		Later	K1B4	71	8.24	11.52	19.94	14.22	33.66	3.37	1.88	.205	1.15	.33	.22	.11	.26	6.88	4.9	141.5
			K2B1	70	8.62	11.13	19.96	14.34	32.54	3.69	1.95	.223	1.34	.30	.21	.09	.96	6.68	4.9	106.4
	Middle	Hand	K1M4	64	6.72	11.53	16.77	9.73	25.81	4.02	1.72	.422	3.84	.66	.31	.35	3.06	5.89	6.4	1.4
			K2M1	61	6.76	11.65	16.18	9.19	26.79	3.89	1.73	.418	3.82	.72	.34	.38	3.14	5.92	4.7	0.7
		Earlier	K1M3	60	6.22	11.68	16.51	10.96	26.38	4.27	1.73	.482	3.79	.77	.41	.36	3.48	5.80	6.7	20.9
			K2M4	64	7.28	11.60	16.98	9.90	27.46	3.61	1.73	.371	3.35	.60	.28	.32	2.70	6.00	6.6	21.3
		Full flower	K1M2	61	6.62	11.78	16.82	11.48	27.74	3.78	1.77	.475	3.40	.63	.32	.31	3.09	6.00	6.6	65.9
			K2M3	63	6.98	11.69	16.77	10.32	26.44	3.69	1.71	.353	3.34	.59	.28	.31	2.53	6.18	7.0	56.9
		Later	K1M1	65	6.68	11.67	17.73	10.97	26.65	3.70	1.86	.407	3.30	.66	.34	.32	2.80	6.00	6.2	200.2
			K2M2	62	6.52	11.64	16.72	11.09	27.46	4.15	1.84	.481	3.56	.68	.39	.29	3.03	5.90	5.9	148.0
	Top	Hand	K1T1	47	5.76	11.08	14.87	9.95	16.94	4.58	1.48	.861	4.96	1.01	.55	.46	4.60	5.41	7.8	7.8
			K2T2	46	5.80	11.12	14.87	10.25	22.72	4.36	1.58	.699	4.54	.92	.49	.43	4.03	5.61	7.5	4.0
		Earlier	K1T4	47	5.74	11.36	14.74	10.36	22.24	4.40	1.58	.828	4.73	.97	.55	.42	4.42	5.56	7.0	35.5
			K2T1	45	5.68	11.31	14.74	9.01	22.64	4.26	1.55	.752	4.32	.93	.50	.43	4.31	5.50	7.8	28.0
		Full flower	K1T3	45	5.76	11.22	14.75	8.42	21.96	4.43	1.54	.830	4.43	.90	.49	.41	4.23	5.59	7.4	68.0
			K2T3	46	6.00	11.39	14.98	8.40	21.31	4.23	1.53	.755	4.21	.92	.52	.40	4.03	5.58	7.6	64.1
		Later	K1T2	46	5.74	11.38	14.82	9.37	22.72	4.61	1.53	.836	4.36	1.02	.60	.42	4.21	5.59	7.7	268.6
			K2T4	46	5.72	11.36	15.11	9.33	22.98	4.81	1.63	.987	4.45	.98	.59	.39	4.34	5.61	7.0	232.2
Princeton, Ky.	Bottom	Hand	PB4	70	6.72	11.21	18.74	11.83	37.89	2.98	1.24	.265	3.57	.68	.35	.33	2.00	6.39	6.4	5.1
		Earlier	PB3	67	6.66	11.35	19.52	13.78	37.63	3.02	1.28	.380	3.17	.64	.39	.25	2.03	6.45	6.0	60.6
		Full flower	PB1	66	6.92	11.45	18.90	15.88	37.49	3.06	1.26	.366	3.15	.58	.29	.29	1.97	6.41	6.5	168.0
		Later	PB2	70	6.52	11.33	18.94	13.55	37.62	3.05	1.28	.343	3.58	.67	.36	.31	2.27	6.39	6.6	136.3
	Middle	Hand	PM1	59	6.52	11.72	15.60	14.24	32.90	3.48	1.09	.425	5.40	.94	.45	.49	3.50	6.14	7.1	3.3
		Earlier	PM4	56	6.22	11.70	15.97	12.48	32.47	3.48	1.20	.556	4.09	.89	.51	.38	3.18	6.18	7.6	48.2
		Full flower	PM3	58	6.68	11.74	15.60	12.32	32.68	3.50	1.09	.476	4.76	.92	.47	.45	3.37	6.20	7.8	81.6
		Later	PM2	58	6.24	11.88	15.26	13.30	32.03	3.59	1.18	.490	5.44	.95	.46	.49	3.67	6.00	8.1	84.3
	Top	Hand	PT4	41	5.76	11.93	13.30	13.05	27.49	4.28	1.27	.705	5.98	1.14	.57	.57	4.39	5.78	7.5	2.6
		Earlier	PT1	45	5.82	11.39	12.60	11.64	24.02	4.10	1.44	.705	3.84	.90	.54	.36	3.36	5.88	7.8	54.4
		Full flower	PT2	42	5.88	11.88	13.01	12.65	24.77	4.16	1.30	.711	5.08	1.05	.57	.48	4.16	5.70	7.8	48.0
		Later	PT3	41	5.66	12.00	13.33	11.86	26.60	4.31	1.27	.781	5.82	1.21	.77	.44	4.79	5.68	7.7	52.0
Point Pleasant, W. Va.	Bottom	Hand	WB3	73	6.98	11.36	20.27	15.97	34.00	3.61	1.26	.253	3.29	.78	.45	.33	2.13	6.25	5.3	7.7
		Earlier	WB2	73	7.00	11.58	20.49	16.44	34.57	3.64	1.29	.290	3.02	.75	.46	.29	1.94	6.30	5.2	15.8
		Full flower	WB1	70	6.48	11.89	20.47	15.05	33.43	3.69	1.28	.312	3.90	.84	.51	.33	2.13	6.40	4.9	76.1
		Later	WB4	74	6.58	11.76	19.81	15.08	33.85	3.80	1.26	.324	3.98	.88	.49	.39	2.56	6.20	5.7	50.5
	Middle	Hand	WM1	51	6.12	11.90	17.41	17.22	32.16	3.86	1.18	.399	5.66	1.13	.60	.53	3.32	6.11	6.7	2.4
		Earlier	WM3	48	5.48	12.16	17.31	14.95	31.29	4.19	1.19	.546	5.36	1.28	.76	.52	3.10	6.12	6.8	12.1
		Full flower	WM4	48	4.80	12.52	16.89	13.40	29.88	4.33	1.06	.552	6.61	1.32	.71	.61	4.07	5.88	7.2	34.9
		Later	WM2	49	5.30	12.70	16.60	16.78	29.54	4.34	1.16	.522	6.84	1.33	.68	.65	4.30	5.90	7.0	28.9
	Top	Hand	WT4	41	5.20	11.80	16.12	15.33	28.67	4.27	1.20	.568	5.86	1.33	.78	.55	3.78	5.92	8.2	4.0
		Earlier	WT1	36	4.80	11.90	15.30	12.24	26.61	4.43	1.39	.620	5.01	1.28	.80	.48	2.93	6.29	8.1	11.7
		Full flower	WT2	34	4.50	12.43	14.87	14.36	27.11	4.72	1.28	.722	6.93	1.50	.85	.65	4.50	5.78	8.2	43.7
		Later	WT3	34	4.62	12.46	15.17	12.73	25.89	4.69	1.22	.685	7.28	1.53	.85	.68	4.60	5.80	8.0	26.1
Glade Spring, Va.	Bottom	Hand	AB1	62	6.16	12.19	19.06	14.81	33.21	3.98	1.53	.320	3.80	.72	.39	.33	2.06	6.58	5.2	3.4
		Earlier	AB2	61	6.62	12.49	19.26	16.23	32.66	3.79	1.58	.399	3.15	.69	.42	.27	1.92	6.55	4.8	31.6
		Full flower	AB3	67	6.52	12.27	19.36	15.85	33.26	3.75	1.55	.385	3.27	.70	.40	.30	1.87	6.60	4.9	15.5
		Later	AB4	69	6.76	11.90	20.17	16.69	36.01	3.66	1.64	.337	2.45	.58	.37	.21	1.63	6.62	4.5	15.4
	Middle	Hand	AM4	43	5.80	12.47	15.43	12.39	27.99	4.36	1.33	.534	6.10	1.16	.59	.57	3.62	6.21	6.6	2.1
		Earlier	AM3	38	5.56	12.70	16.11	11.43	26.55	3.99	1.27	.580	4.65	1.01	.59	.42	3.38	6.08	6.8	26.1
		Full flower	AM2	39	5.68	12.45	16.58	14.36	28.67	3.92	1.28	.513	5.18	1.02	.56	.46	3.32	6.21	6.6	15.3
		Later	AM1	44	5.76	11.99	16.79	14.36	29.40	3.70	1.31	.424	4.16	.86	.46	.40	2.81	6.31	6.3	9.7
	Top	Hand	AT2	38	5.10	12.14	14.72	11.92	25.41	4.48	1.31	.669	6.25	1.27	.71	.56	4.35	5.88	7.4	0.8
		Earlier	AT4	38	5.26	12.30	15.34	10.11	22.79	4.21	1.40	.656	4.46	1.06	.65	.41	3.74	5.82	6.8	47.5
		Full flower	AT3	33	4.94	12.18	15.11	11.38	24.91	4.21	1.28	.663	5.36	1.17	.66	.51	3.95	5.90	7.6	14.4
		Later	AT1	40	5.44	11.89	15.60	13.44	27.21	4.01	1.33	.663	4.41	10.5	.63	.42	3.44	6.00	7.3	9.7
Upper Marlboro, Md.	Bottom	Hand	MB1	33	7.84	11.73	18.01	12.41	24.94	1.83	1.04	.129	1.38	.27	.14	.13	1.50	6.11	7.8	3.0
		Earlier	MB3	36	7.44	11.48	17.35	11.42	24.30	1.85	1.00	.143	1.49	.30	.16	.14	1.50	6.05	7.3	13.9
		Full flower	MB2	34	7.50	11.68	17.83	11.68	24.53	1.86	1.07	.138	1.31	.29	.16	.13	1.49	6.10	7.7	38.0
		Later	MB4	35	7.24	11.76	17.94	12.54	24.68	1.76	.99	.117	1.25	.27	.15	.12	1.18	6.11	7.9	104.7
	Middle	Hand	MM2	36	6.90	11.56	16.22	10.15	21.33	2.08	1.07	.166	1.81	.39	.21	.18	1.34	5.90	8.0	5.5
		Earlier	MM4	35	6.76	11.41	16.30	9.23	20.95	2.03	1.00	.165	1.63	.37	.22	.15	1.43	5.78	7.0	15.3
		Full flower	MM3	33	6.64	11.34	16.26	8.21	19.17	2.20	1.01	.196	2.10	.43	.25	.18	2.22	5.68	6.6	48.8
		Later	MM1	34	6.82	11.41	16.42	9.39	19.85	2.11	1.02	.179	1.93	.40	.20	.20	2.19	5.65	7.6	106.7
	Top	Hand	MT3	36	6.12	11.51	14.72	7.34	18.01	2.54	1.13	.317	1.77	.49	.31	.18	3.03	5.25	6.2	2.8
		Earlier	MT2	35	5.64	11.43	13.98	6.84	17.28	2.63	1.16	.357	1.60	.51	.35	.16	2.98	5.18	6.2	16.5
		Full flower	MT1	32	5.68	11.38	13.87	6.33	16.01	2.87	1.20	.339	1.84	.58	.40	.18	3.19	5.12	6.2	88.4
		Later	MT4	34	5.84	11.47	15.28	9.49	20.04	2.48	1.09	.308	1.76	.49	.32	.17	2.86	5.20	6.3	65.2

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[1] Hand = Topped at full flower and hand suckered whenever suckers were 4 to 6 inches long.
Earlier = Sprayed with maleic hydrazide about a week before full flower, topped at full flower.
Full flower = Topped at full flower and sprayed with maleic hydrazide immediately after topping.
Later = Topped at full flower and sprayed with maleic hydrazide one week later, suckered then if necessary.

Table 12.--Mean values of the results of physical and chemical determinations on air-cured tobacco samples derived from different positions on the plant and different sucker control treatments [1/]

Determination	Bottom				Middle				Top				Whole plant			
		Time of maleic hydrazide treatment				Time of maleic hydrazide treatment				Time of maleic hydrazide treatment				Time of maleic hydrazide treatment		
	Hand suckered	1 week earlier	At full flower	1 week later	Hand suckered	1 week earlier	At full flower	1 week later	Hand suckered	1 week earlier	At full flower	1 week later	Hand suckered	1 week earlier	At full flower	1 week later
Color	62	61	60	62	51	48	49	50	40	40	38	39	51	50	49	50
Specific volume	7.54	7.41	7.45	7.39	6.65	6.44	6.57	6.43	5.73	5.63	5.65	5.62	6.64	6.49	6.56	6.48
Moisture equilibrium at 60% RH (%)	11.73	11.81	11.85	11.80	11.93	12.00	11.98	12.02	11.75	11.92	11.85	11.92	11.81	11.91	11.89	11.91
Total ash (%)	20.10	20.54	20.50	20.68	16.67	16.81	16.87	17.01	14.93	14.34	14.69	15.16	17.23	17.23	17.35	17.62
Alk. of water sol. ash (meq/10g)	13.98	14.19	13.87	14.26	12.28	11.37	11.85	12.55	10.81	9.58	10.26	10.68	12.36	11.71	12.00	12.50
Alk. of total ash (meq/10G)	34.17	34.05	33.72	34.46	28.67	27.90	28.03	28.19	24.11	22.06	23.14	24.55	28.98	28.00	28.29	29.07
Total N (%)	3.07	3.03	3.02	3.10	3.55	3.57	3.46	3.57	4.13	4.06	4.00	4.20	3.59	3.55	3.49	3.63
Acid insol. N. (%)	1.40	1.44	1.41	1.43	1.34	1.32	1.27	1.33	1.32	1.49	1.35	1.34	1.36	1.42	1.34	1.37
Alpha amino N (%)	.228	.264	.261	.258	.408	.480	.430	.447	.687	.694	.675	.756	.441	.479	.455	.487
Total alkaloids (%)	2.40	2.10	2.20	2.23	4.29	3.64	3.96	4.07	4.68	3.55	4.23	4.49	3.79	3.10	3.46	3.59
Total volatile bases (% as NH_3)	.50	.49	.49	.50	.84	.82	.82	.84	1.06	.96	1.01	1.08	.80	.75	.77	.81
TVB-Nicotine (%)	.28	.30	.29	.30	.44	.48	.45	.46	.62	.62	.61	.67	.45	.47	.45	.48
Nicotine in TVB distillate (%)	.22	.19	.37	.36	.40	.34	.37	.38	.44	.33	.40	.41	.35	.29	.38	.38
Water soluble acids (meq/10g)	1.31	1.26	1.28	1.28	2.83	2.74	2.86	2.92	3.88	3.46	3.71	3.84	2.68	2.49	2.62	2.68
pH	6.74	6.78	6.82	6.81	6.14	6.07	6.13	6.09	5.70	5.73	5.70	5.72	6.19	6.19	6.22	6.21
Pet. ether extract (%)	5.9	5.7	5.8	5.8	6.6	6.8	7.1	6.8	7.2	7.0	7.3	7.1	6.6	6.5	6.7	6.6
Maleic hydrazide (ppm)	6.1	26.9	56.6	84.2	3.2	26.9	42.7	87.4	4.3	44.2	49.3	111.4	4.5	32.7	49.5	94.3

[1/] The mean values, which are underlined, differ significantly by statistical test from the corresponding values for hand-suckered tobacco samples.

MANUFACTURE AND EVALUATION OF THE CIGARETTES

Preparation of Cigarette Blends.--After the samples for laboratory analysis were removed, the remaining portions were combined into 12 groups according to the 4-sucker-control treatments and 3 tobacco types. Again the flue-cured tobacco samples from Virginia had to be omitted as the absence of the "earlier" treatment prevented the use of any of this tobacco in the blended cigarettes without causing a dissimilarity other than that resulting from sucker-control treatment between some of the blends to be tested subsequently in cigarettes.

The proportions of leaf from different parts of the plants differed in the cigarettes made from the 1961 crop from those made in the previous experiment. In 1960, if a greater weight of leaf was produced on the top part of the MH-treated plants than on the hand-suckered plants, the extra tobacco was discarded to maintain the same proportion in the cigarettes of leaf from different positions. With the increasing competition for tobacco available for cigarette manufacture and the decreasing consumption of leaf of these types for other purposes, leaf from different plant portions is being used for cigarette manufacture much more nearly in the proportion in which it is grown and marketed. Thus, tobacco from the 1961 crop was blended in the proportions of leaf from different plant positions in which the leaf grew in the experimental plots. These proportions are shown in table 13.

Table 13.--Proportion by weight of tobacco from different sources in final cigarette blends

Part of blend	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
	%	%	%	%
By type:				
Flue-cured	60.0	60.0	60.0	60.0
Burley	35.0	35.0	35.0	35.0
Maryland	5.0	5.0	5.0	5.0
By location of field:				
Gainesville, Fla.	5.6	7.0	6.7	5.8
Tifton, Ga.	18.5	16.1	18.5	19.0
Florence, S. C.	20.0	19.6	18.7	18.1
Whiteville, N. C.	15.9	17.3	16.1	17.1
Waynesville, N. C.	7.0	7.5	5.9	6.0
Greeneville, Tenn.	5.3	5.2	4.9	5.6
Lexington, Ky.	4.0	3.6	3.6	3.7
Princeton, Ky.	5.6	5.1	5.5	5.1
Glade Spring, Va.	7.9	7.2	9.2	9.8
Point Pleasant, W. Va.	5.2	6.4	5.9	4.8
Upper Marlboro, Md.	5.0	5.0	5.0	5.0
By part of plant and type:				
Bottom:				
Flue-cured	15.6	13.7	14.2	12.0
Burley	14.8	13.8	13.6	13.6
Maryland	1.8	1.8	1.5	1.6
All types	32.2	29.3	29.3	27.2
Middle:				
Flue-cured	22.2	17.6	18.6	23.0
Burley	10.4	11.2	10.8	11.8
Maryland	1.4	1.5	2.0	1.6
All types	34.0	30.3	31.4	36.4
Top:				
Flue-cured	22.2	28.7	27.2	25.0
Burley	9.8	10.0	10.6	9.6
Maryland	1.8	1.7	1.5	1.8
All types	33.8	40.4	39.3	36.4

One can see near the bottom of the table that the proportion of leaf from the top part of the flue-cured tobacco plant was increased considerably (28.7, 27.2, and 25.0 percent of the total blend for the three MH treatments) compared with hand-suckered tobacco (22.2 percent). There was no significant difference related to suckering treatments in proportion of tobacco of the farm grades from the top part of the plants of the air-cured types.

After blending the leaf from different parts of the plant and from different locations within each tobacco type, the 12 blends (3 types and 4 treatments) were redried to the standards used for the 1960 crop. A 25-pound subsample of each of the 4 flue-cured blends was sent to the United Kingdom manufacturers for evaluation because of the importance of the export market for flue-cured tobacco.

Accelerated aging was conducted at the same temperatures and humidities used previously (90° F. and 70% R.H. for flue-cured, and 95° F. and 75% R.H. for air-cured). The aging period extended from December 12, 1961, to January 26, 1962. Subsamples of the four burley blends and the four Maryland blends, after removal from accelerated aging, were prized and placed in open storage for additional aging and possible future use in making straight-type cigarettes. This was done because of the questions raised about the effects of the sucker-control treatments on the smoking properties of the individual tobacco types.

The casing and blending of each of the three types of tobacco were conducted in the manner described in the previous report. This resulted for each of the 4 sucker-control treatments in one final blend containing tobacco from all plant positions grown at 11 locations as shown in table 13.

The physical and chemical properties of the blended and cased tobacco ready for cigarette manufacture are shown in table 14. The percent reducing sugar and the moisture on equilibration at 63 percent relative humidity are higher for the tobacco from all MH-treatments than for the hand-suckered tobacco. The ash, total volatile acids, color or brightness as measured by Agtron number, and the specific volume or filling power are lower. In addition, the total volatile bases and nicotine are lower for the tobacco from the earlier time of treatment but are not appreciably different for that from the other two times. These trends are remarkably similar to those observed in the previous year (table 6 of the report on the 1960 crop[6/]).

[6/] See footnote 2, p. 6.

Table 14.--Comparison of the physical and chemical properties of the blended tobacco used in experimental cigarettes

Determination	Hand suckered	Time of maleic hydrazide treatment: 1 week earlier	At full flower	1 week later
Total volatile base (as NH_3) (%)	0.481	0.445	0.484	0.476
Nicotine (%)	2.66	2.33	2.62	2.73
TVB minus nicotine (%)	.202	.200	.209	.189
Ratio of nicotine to TVB	.58	.55	.57	.60
Sugars before inversion (%)	13.8	15.2	16.3	15.0
Ash	15.72	14.45	14.55	15.04
Total volatile acids (as acetic) (%)	.122	.104	.116	.106
Color (Agtron 5007-5034)	67	58	58	61
Moisture as packed (%)	12.80	12.63	12.71	12.33
Moisture equilibrium at 63% RH (%)	13.4	14.5	14.4	13.7
Specific volume (cc/.33g)	1.05	.94	.94	.97

Manufacture of the Blended Cigarettes.--Because of the type of smoking test used on the 1961 tobacco, it was necessary to prepare the cigarettes manufactured from the hand-suckered tobacco with six different code letters and those from each of the MH-treated tobaccos with two code letters. The cigarettes were made, under the observation of a U. S. Department of Agriculture representative, on a commercial cigarette-making machine in the factory of a cooperating manufacturer. Thirty thousand cigarettes, 5,000 bearing each of six code letters, were made of hand-suckered tobacco. Similarly, 8,000 cigarettes bearing each of two code letters were made from each of the three MH-treated lots.

No serious difficulty was encountered in making cigarettes from the MH-treated tobacco of the 1961 crop, but some changes in adjustments had to be made to obtain cigarettes of equal firmness. Much more difficulty was encountered in making cigarettes from the corresponding samples of the 1960 crop. The following possible explanations of the different results of these two tests may be offered:

(1) The different weather conditions during growth in 1961 may have resulted in the plants being in a different physiological condition which caused them to react to the suckering treatments differently than they did in 1960. It is generally accepted that the results of MH treatment are much more obvious in some years than in others--both in the field and in the cured leaf.

(2) Leaf from the bottom part of the plant was included in the blends of tobacco from the 1961 crop in contrast to the experimental blends of the 1960 crop when such leaves were not used. Since this more mature leaf is not affected so much by MH treatment, it diluted the mixture to a point where all blends were within the limits of physical properties that the machine could handle.

(3) In the manufacture of experimental cigarettes, the first group made in both years was from the hand-suckered tobacco. For the 1960 crop, this was followed by the group MH-treated at the earlier date and then by the others in chronological order. When the cigarettes were made from the 1961 crop, manufacture of the MH-treated groups was in the reverse order; hence the earlier treated lot was the last to be processed. Since this lot was found most difficult to manufacture last year and the operator of the machine, who did not know which sample corresponded to which code number, continuously adjusted the machine in an effort to maintain uniformity of product, the final adjustments may have been more favorable for handling this lot by the time it was reached in 1961.

Physical Properties of the Cigarettes.--Certain physical properties of the cigarettes made from these tobacco blends are shown in table 15. The length and circumference of the cigarettes made of tobacco of the different treatments are similar. An effort was made to manufacture all lots so they would be of equal firmness. This resulted in a greater weight of tobacco being used in the manufacture of the cigarettes from the MH-treated tobacco, but not enough greater to produce uniform "draw," or equal ease of smoking. Calculations based on relations found by previous industrial experience showed that the amount of additional tobacco which would have to be used to make cigarettes out of the MH-treated tobacco of equal draw to the hand-suckered would be 7.3, 9.0, and 6.1 percent respectively. (Table 15). Thus the manufacturer who is trying to produce a product of uniform "draw" for the smoker would find the filling power of the MH-treated tobacco to be 6 to 9 percent less than that of hand-suckered tobacco. However, other manufacturers try to maintain their cigarette production at uniform firmness, or feel of the cigarette between the fingers. For this criterion, the corresponding reductions in filling power for cigarettes made of tobacco MH-treated at the three stages of maturity used in this study relative to cigarettes made of hand-suckered tobacco are 6.9, 6.9, and 4.6 percent respectively.

Table 15.--Comparison of physical properties of experimental cigarettes

Determination	Hand suckered	Time of maleic hydrazide treatment: 1 week earlier	At full flower	1 week later
Length (mm)	70.0	70.0	70.0	70.0
Circumference (mm)	25.71	25.59	25.58	25.68
Weight per cigarette (g)	1.073	1.091	1.095	1.086
Calculated weight per cigarette at 12% moisture (g)	1.063	1.083	1.085	1.081
Moisture content at 65% RH and 75° F. (%)	12.71	14.00	13.43	13.92
"Draw" of cigarette:				
Measured by suction necessary to pull air through cigarette at given rate (cm H_2O). (Low values = easy draw)	8.3	7.8	7.4	8.0
Measured by air flow through cigarette at given suction (cc/sec). (High values = easy draw)	14.3	17.1	18.0	16.5
Calculated air flow at standard conditions 1/	15.8	19.6	20.5	19.0
Calculated filling power to give uniform flow compared with hand suckered 2/	Standard	-7.3%	-9.0%	-6.1%
Compressibility:				
Calculated filling power based on compressibility compared with hand suckering 3/	Standard	-6.9%	-6.9%	-4.6%

1/ Corrected to uniform moisture (12%), uniform circumference (26.75 mm), and uniform cigarette weight (1.040 g/cgt) on basis of other work.

2/ Calculated on basis of other work which indicates that 20-mg difference in tobacco per cigarette will cause a difference in air flow of 1 cc/sec.

3/ Data obtained on cigarettes equilibrated to 65% RH and 75° F. and corrected to uniform density of 0.268 g/cc.

Burning Properties of the Cigarettes.--Data on the burning properties of the cigarettes and the composition of the smoke drawn from them by a smoking machine are given in table 16. The static burn, or time required for these "regular size" cigarettes to burn from the original length of 70-mm. to a 30-mm. butt when not being puffed, was significantly greater for the MH-treated tobacco, especially when treated earlier; however, the difference from hand-suckered was not so great as for the cigarettes made from the 1960 crop.

Table 16.--Comparison of burning properties and smoke composition of experimental cigarettes

Determination	Hand suckered	Time of maleic hydrazide treatment		
		1 week earlier	At full flower	1 week later
Static burn time (min) [LSD(.05) = .24]	12.08	12.72	12.48	12.41
Machine smoking burn rate (mm/min)	3.65	3.56	3.34	3.54
Number of puffs/47 mm.	10.3	9.9	10.0	10.4
Materials in trap:				
Total solids (mg/cig)	38.6	43.0	43.8	41.4
Total solids (mg/l)	106.9	124.3	125.3	113.9
Nicotine (mg/cig)	2.86	2.70	3.23	3.26
Nicotine (mg/l smoke)	7.9	7.8	9.2	9.0
Nicotine transfer (%)	17.2	18.4	19.6	19.0

When these cigarettes are smoked on a machine, the amount of total solids transferred to the main stream smoke, which is comparable with the amount which would enter the mouth of the smoker, is consistently greater from the MH-treated tobacco than from the hand-suckered tobacco. This change is considered to be in an undesirable direction. The amount of nicotine transferred to the smoke from tobacco of the last two treatments also appears to be higher. Neither of these effects was observed on the tobacco from the 1960 crop.

Smoking Panelists' Evaluation of the Cigarettes.--The cigarettes were smoked by individuals who had been preselected for their ability to discriminate cigarettes made of lots of tobacco that differed from each other. This resulted in the panels being composed of persons associated with the cigarette manufacturers, the tobacco exporters, or a consulting firm retained by the manufacturer of maleic hydrazide. The cigarettes were smoked under a randomized code involving tests of cigarettes made of hand-suckered tobacco compared successively with those made of tobacco from plots of each one of the three times of MH treatment. Each smoker was asked to smoke a number of cigarettes (at least three) of one code letter and an equal number of those of another letter, and then report his preference between the cigarettes of this code pair. He was also asked to report his reaction to the cigarettes of the code letter of the pair which led him to consider it less satisfactory. The 12 code letters were so arranged that when he had completed smoking the various lots in alphabetical order, evaluating them as 6 pairs, he had compared the cigarettes made of hand-suckered tobacco with those made of tobacco from each of the MH-treated lots. Furthermore, he had smoked tobacco from each of the MH treatments first at one time and that from the hand-suckered treatment in comparison with the same MH treatment first at another time. The preferences expressed by the expert smoking panel members are shown in table 17.

Table 17.--Preferences of smoking panel members for cigarettes made of hand-suckered tobacco and for those made from tobacco treated with maleic hydrazide

Treatment and smoking order	Code	Preference 1/		
		Hand suckered	None	MH treated
Hand vs. MH earlier:				
Hand-suckered, smoked first	EF	64	26	44
Hand-suckered, smoked second	GH	48	25	61
Total		112	51	105
Hand vs. MH at full flower:				
Hand-suckered, smoked first	AB	94	14	26
Hand-suckered, smoked second	IJ	60	30	44
Total		154	44	70
Hand vs. MH later:				
Hand-suckered, smoked first	KL	68	27	39
Hand-suckered, smoked second	CD	72	32	30
Total		140	59	69
Hand vs. all MH:				
Hand-suckered, smoked first		226	67	109
Hand-suckered, smoked second		180	87	135
Total		406	154	244

1/ The values which are underlined differ significantly at the 5-percent level.

Some panelists reported "no preference" to certain code pairs. For statistical analysis the preferences were converted to "normal scores." On this basis the "no preferences" were given the score zero, which is the average of the other two normal scores. This has the effect of assigning the "no preferences" equally to each of the categories. When this was done and the probability of each distribution estimated, many differed significantly at the 5-percent level (table 17). This would indicate significant preference for cigarettes made of hand-suckered tobacco over those made of tobacco MH treated at full flower or especially later, but would not indicate significance when hand-suckered tobacco was compared with that treated with MH at the earlier time.

From the standpoint of times of application at which significant preference was demonstrated, these results are opposite from those obtained on the 1960 crop. From another standpoint, they indicate that the use of MH may have measurable effects on the suitability of tobacco on which it is used at any time it is likely to be used. The occurrence of measurable effects would probably depend on seasonal conditions.

These results illustrate the difficulties involved in subjective evaluation of tobacco by smoking tests. The data presented in table 17 shows a statistically significant preference of the panelists for the member of the pair which they smoked first. This occurred in spite of the use of the most experienced and largest smoking panel that has ever been used to study a problem of tobacco quality.

The plans for this test anticipated the possibility that the order of smoking of the cigarettes would influence the individual's opinion. An equal number of reports were obtained from comparisons in which cigarettes made from hand-suckered tobacco were smoked first as from those in which cigarettes made from MH-treated tobacco were smoked first. Thus the conclusion that preference was shown for hand-suckered tobacco over the two later times of MH treatment is valid in spite of the preference also shown for the first-smoked member of a pair.

The form of the question and the natural attitude of persons on test panels combined to bring out all possible critical adjectives. So many different ones were used that it was necessary to classify them as to meaning to be able to present them in a table. An arbitrary classification was attempted with the results shown in table 18. Often a panelist gave more than one criticism, and all are recorded in the table; consequently, the total number of observations is larger than the number of panelists times sample pairs.

Table 18.--Panelists' criticisms of smoking characteristics of cigarettes made of hand-suckered and maleic hydrazide-treated tobacco

Type of criticism	Number of panelists reporting criticism of cigarettes made of tobacco treated in the manner indicated when compared with other of code pair					
	Hand suckered	MH earlier	Hand suckered	MH at full flower	Hand suckered	MH later
Harsh, hot, irritating, sharp, tart, peppery, acrid, burns throat	49	64	44	108	35	92
Strong, bitter, pungent, rank	33	41	24	53	15	48
Weak, flat, tasteless, less flavor, less aroma	10	21	14	8	12	13
Off-flavor, bad, disagreeable	15	16	10	11	7	17
Slightly poorer, less desirable, not as good	15	12	6	17	9	22
Musty, stale, woody, weedy, haylike, medicinal, metallic, unaged, green	27	30	5	43	9	28
Dry aftertaste, odd aftertaste, causes dryness	10	11	9	12	12	17

The results indicate that the terms "harsh," "hot," "irritating," etc., and those such as "strong" and "bitter" are more frequently applied to the cigarettes made of MH-treated tobacco than to those made of hand-suckered tobacco. Objections of these types are more numerous to the cigarettes from the later times of treatment, whereas many of the others appear to be about equally divided among the samples.

EVALUATION OF FLUE-CURED BLENDS BY UNITED KINGDOM MANUFACTURERS

Since one of the most important problems resulting from the use of maleic hydrazide is the objection raised by foreign purchasers of U. S. tobacco, arrangements were made to supply, under code, to the Tobacco Advisory Committee of the United Kingdom manufacturers for their evaluation, subsamples of the flue-cured blend from each of the four treatments. This Committee is composed of representatives of the principal manufacturers in that country, and its report represents a joint effort to evaluate this tobacco. The analytical data supplied to the U.S. Department of Agriculture are shown in table 19.

Table 19.--Results of tests by the Tobacco Advisory Committee of the United Kingdom manufacturers on the flue-cured blends expressed as percentage of figures on the blend of hand-suckered tobacco compared with figures for similar U. S. determinations 1/

Determination	Time of maleic hydrazide treatment					
	United Kingdom figures			United States figures		
	Earlier	Full flower	Later	Earlier	Full flower	Later
Filling value at 60% RH	93.6	91.6	95.1	91.2	90.1	93.4
Equilibrium moisture at 60% RH	105.2	106.1	104.0	104.9	106.9	105.0
Ash	89.3	92.0	95.3	94.9	90.1	93.4
Ash alkalinity	86.5	87.2	85.3	93.6	92.6	96.5
Acid insoluble N	99.4	99.0	99.8	99.4	101.6	99.7
Total alkaloids	91.9	103.3	108.6	93.8	103.5	107.0
Total volatile bases	88.0	98.3	99.2	90.4	97.2	99.2
Sugars	130.8	128.3	111.8	120.8	120.1	111.7
Sugar/nicotine	141.3	123.8	102.5	128.6	116.1	104.2
Sol. non-volatile N.	90.4	96.8	98.9			
SiO_2	91.2	90.8	77.9			
CaO	83.4	85.2	93.1			
K_2O	98.9	100.0	99.7			
SO_3	89.4	92.5	96.3			
Cl	71.4	82.9	88.6			
Draw resistance of cigarettes	66.6	62.5	74.1			

1/ The U. K. figures were determined on a single sample for each treatment of blends containing the proportions of tobacco from different locations and parts of the flue-cured plant shown in table 13. The U. S. figures are arithmetic means of separate analyses on all the samples from which the blends were prepared. The U. S. figures that were statistically different from the corresponding figure for hand-suckered tobacco are underlined; no such statistical test was applied to the sugar/nicotine ratio.

This study was conducted on a different basis from that employed in the previously discussed chemical determinations. Only a single blended sample of each treatment was supplied to the United Kingdom manufacturers. Thus no information is available for the assignment of the order of reliability of the differences observed. To compare the United Kingdom results as well as possible with the U. S. results, the means of all leaf levels derived from table 10 are calculated to percentage of the hand-suckered values and shown in the right half of table 19 when similar determinations were conducted in the two tests. Since the analytical methods were different and the blended samples contained different weights of tobacco from different locations and plant positions, the figures cannot be expected to agree completely. However, the following conclusions contained in the United Kingdom report are in agreement with the findings in this country:

(1) The total ash and ash alkalinity of the blends of MH-treated tobacco were lower than those of the hand-suckered blend.

(2) The total sugar, sugar to nicotine ratio, and moisture on equilibration at 60-percent relative humidity were higher for the treated blends.

(3) The filling value and draw resistance of the cigarettes manufactured from the treated blends were lower than those of the hand-suckered blends.

In addition to the data in the table, the report stated that no difficulty was encountered in manufacturing cigarettes from one lot, indicated by code number, but stated that difficulty in weight control was encountered manufacturing cigarettes from the other lots. The former was the hand-suckered lot. No differences in smoking quality of the manufactured cigarettes were observed in this test. However, the smoking tests were not nearly so extensive as in this country.

The values for draw resistance in the U. K. tests (table 19) are much lower than would be calculated from the U. S. tests (line 6 table 15). The cigarettes were made in the U. K. to equal weight, whereas those made in the U. S. were made as nearly as possible to equal firmness; therefore, the U. S. cigarettes made from MH-treated tobacco were of greater weight and consequently of more nearly normal draw resistance.

The report also stated that these samples did not represent so wide a range in properties between samples containing MH and those free from MH as they had observed on farmer-grown tobacco. Possible explanations include (1) the closer attention to time of application and amount of the chemical used, which can be obtained on small plots supervised by research workers, compared to practices on commercial farms, and (2) interactions of the effects of the chemical with those of other farm practices that are not conducive to tobacco suitability for cigarette manufacture.

DISCUSSION

The purpose of this report, like that of the one which preceded it, is different from that of most agricultural research. This research was designed to determine whether a new practice, when conducted as nearly according to directions as it is likely to be done in practice, has a demonstrable adverse effect on the suitability or quality of the crop when compared to a standard practice. Most agricultural research is conducted to determine how to carry out a practice to gain the maximum advantage from it for the purpose of making recommendations to the farmer. Previous experiments had indicated that time of application of MH rather than rate of application was the more critical variable in determining tobacco quality. Thus three times of application were used, but they were no further apart than the degrees of maturity that might be present in different plants in a given field. The samples from the three MH treatments represented the results that farmers might obtain when they followed directions as closely as possible in view of existing weather, labor supply, and field variability; thus the samples were markedly superior to the crops that would be produced by careless application.

The results obtained from the 1961 crop differ in detail from those obtained from the 1960 crop, but the only important difference is in the smoker's preferences or objections. When the 1960 crop tobacco from each time of MH treatment was compared in blended cigarettes with hand-suckered tobacco, the smokers discriminated to a statistically significant degree against the earlier treatment, but not against the two later treatments. In cigarettes made from the 1961 tobacco the panelists discriminated against the two later times of treatment, but not the earlier. It may be claimed that these results are conflicting, but they are scarcely more so than many field tests dependent on seasonal conditions. For example, in fertilizer tests the amount of fertilizer that must be applied to produce a maximum yield is much different in different years. In the present case the important conclusion from the standpoint of suitability for manufacture, or quality, is that in both years there was a time, within the limits of maturity at which the chemical is frequently applied, when statistically significant discrimination against the MH-treated tobacco was observed. The results herein presented do not provide evidence as to whether the objection on the part of the smoker would be sufficient to affect cigarette consumption. However, they indicate that the present efforts of tobacco manufacturers in many countries to purchase only tobacco on which this chemical has not been used are based on a reasonable attempt to maintain product quality.

The results of laboratory determinations show nearly the same trends related to sucker-control treatment in the two crops. Only two leaf levels of the 1960 crop were analyzed, and mean figures were not presented for the levels separately. Thus, table 3 of the previous report may be compared with the whole plant portion of table 10 of this report. All determinations, except alkalinity of the water-soluble ash, in which statistically significant differences were observed in flue-cured tobacco of the 1960 crop were also observed in the 1961 crop. For the air-cured tobacco, the whole-plant results, with the exception of those for total nitrogen, were similar for the two crops. (Compare table 12 of this report with table 4 of the previous report.)

The amount of difference in analytical values between the hand-suckered and MH-treated samples is less in air-cured than in flue-cured tobacco. Sugars, present in large quantity in flue-cured tobacco and consistently affected by suckering treatment, are practically absent from properly air-cured tobacco. Differences in sugar content undoubtedly explain a part of the differences in moisture equilibrium and in specific volume related to suckering practice in flue-cured tobacco. The difference in filling power related to sucker-control method averaged 8.5 percent in flue-cured tobacco in the 1961 crop, but was only 2.0 percent in the air-cured tobacco. Leaf experts showed much more preference for hand-suckered flue-cured tobacco than they did for air-cured tobacco. Thus, present evidence indicates that the effect of MH on the suitability of burley and Maryland tobacco is probably less pronounced than on flue-cured tobacco. More information will be obtained on the effect of MH on the suitability of air-cured tobacco for cigarette manufacture when the subsamples of burley and Maryland tobacco have been more completely aged, made into cigarettes, and smoked.

The effects of chemical sucker control on filling power and moisture content are obviously of economic importance since the cigarette manufacturer buys tobacco by the pound but sells it by volume. The chemical analyses give fairly precise numerical results and so show clearly that MH-treated tobacco is different from hand-suckered tobacco. In the absence of adequate data in the scientific literature to connect the levels of these components with smoking properties, they do not prove conclusively which tobacco is more suitable for cigarette manufacture.

In a situation such as this it is inevitable that the manufacturers will attempt to maintain uniformity in their present products with the composition which existed when their products attained popularity until a more fundamental measure of acceptability is available.

The preparation of the statistical analyses on the physical and chemical characteristics of the tobacco from the experimental plot required several assumptions. In addition to the standard assumptions implied when analyses of variance are used (normality, additivity, independence and homogeneity of variance), the locations were assumed to provide a representative sample of the effects of the treatments applied. An additional set of samples from a State (North Carolina, Tennessee, and Lexington, Kentucky) were considered in the same way as an additional location.

In some analyses, bottom, middle, and top leaves were evaluated as separate entries. In other analyses the effect over the whole plant was considered and in such combined analyses, middle, bottom, and top were considered as positions on the plant.

Because of the nature of the experiment, the three treatments (applications of MH) were considered to be similar in concept and were contrasted against hand suckering. In statistical terms, this involved subdividing the three permitted contrasts among treatment means into one contrast between the mean of the hand-suckered treatment and the mean of all the MH treatments, and two contrasts among the MH treatment means.

The data in the form of scores as provided by the leaf experts were not converted to normal scores before the application of the analysis of variance; therefore, the probability levels for the significance tests may be slightly disturbed. The discrimination obtained seemed sufficiently clear to permit the inferences reported.

The preferences reported by the smoking panel members were converted to normal scores before the analyses were made. The conclusions drawn and reported were based on the transformed data.

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